North Dakota State University Report for United States Fish and Wildlife Service

Title: **Influence of Land-use Practices on Site Occupancy of Dakota Skippers and Other Prairie Dependent Butterflies**

Dates Covered in Report: June 1st, 2015 – December 8th, 2017

Objectives

1) Use occupancy modeling with environmental covariates to get unbiased estimates of the number of sites potentially occupied by Dakota skippers

2) Use line-transect distance sampling to calculate prairie dependent butterfly densities while accounting for imperfect detection

Methods

In 2015, we selected sites on U.S. Fish and Wildlife Service (USFWS) refuges throughout the Dakotas to conduct our research (Fig 1). We systematically eliminated sites that did not have enough room to conduct surveys (≤20 ha) or are composed entirely of open-water habitats. From the remaining USFWS sites, we randomly selected 20 sites, focusing our efforts mainly east of the Missouri River to correspond with the Dakota skipper range. After one year of surveying, we eliminated sites that lacked butterfly diversity and were highly invaded by exotic plants and selected additional survey sites that were known to have higher levels of plant diversity. These new sites were privately and publicly owned and were not exclusively USFWS lands. In 2016, we surveyed 25 sites—14 sites from 2015 and 11 new sites. We surveyed four new sites in 2017, removing three sites from 2016 for a total of 26 sites. Within each site, we placed four random points to become the starting points for surveys.

We visited sites three times between June and early August, rotating the time of day and order of surveys to reduce temporal bias. Furthermore, we conducted surveys during optimal field conditions for butterflies - between 0900 and 1800 hours (CDT), when air temperatures were between 21 - 35 °C, winds were under 25 $km \cdot hr^{-1}$, and cloud cover was less than 50%. We conducted butterfly surveys with two observers using line-transect distance sampling (LT) and visual encounter surveys (VES). For each site, there was 2- 100 meter LT transects and 2- 4 hectare VES plots (Fig 2). One observer surveyed one LT and one VES (subplot) each visit. On subsequent site visits, observers rotated which subplot they surveyed to reduce observer bias.

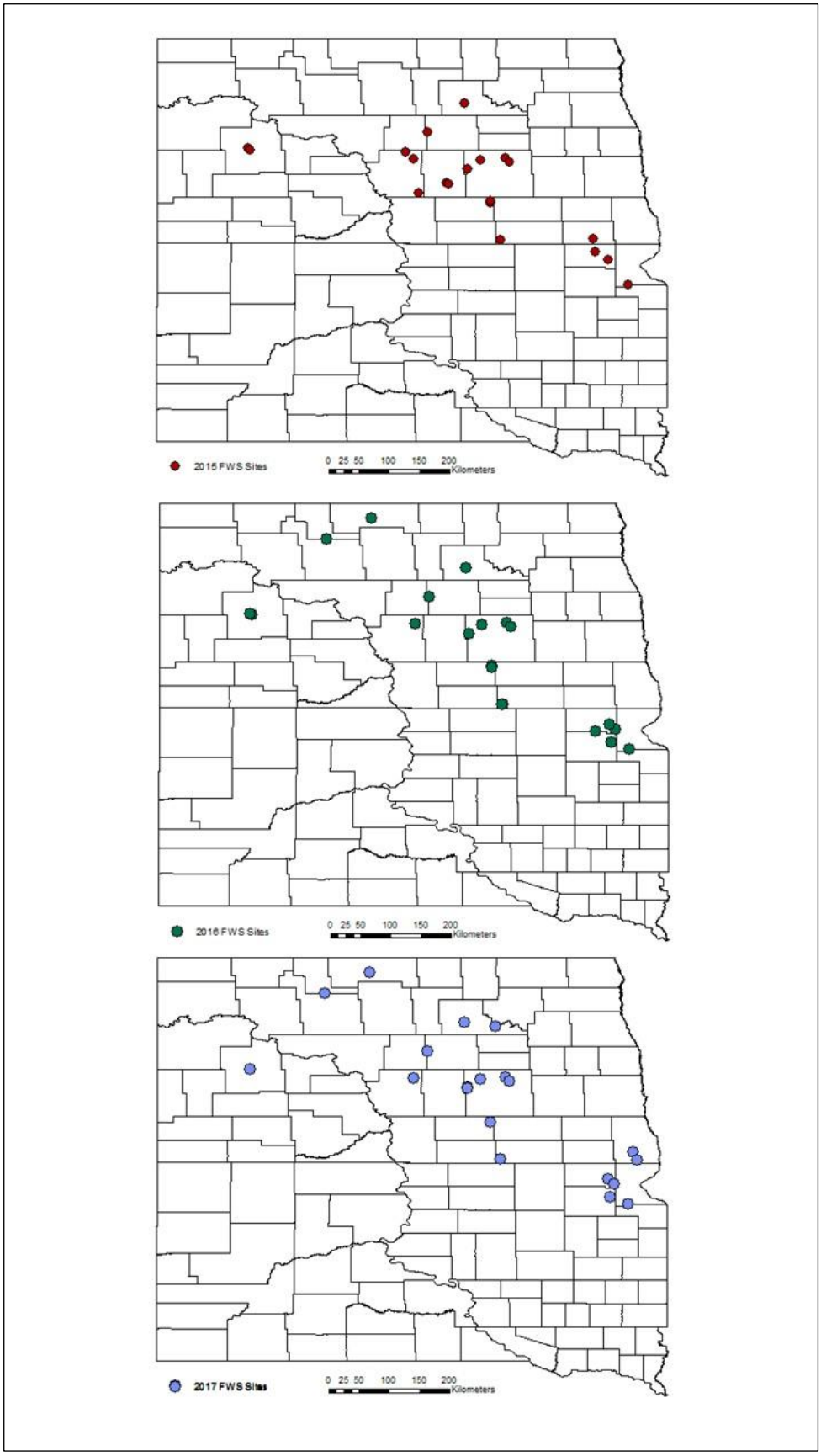

Fig 1. Location of butterfly survey conducted from 2015-2017.

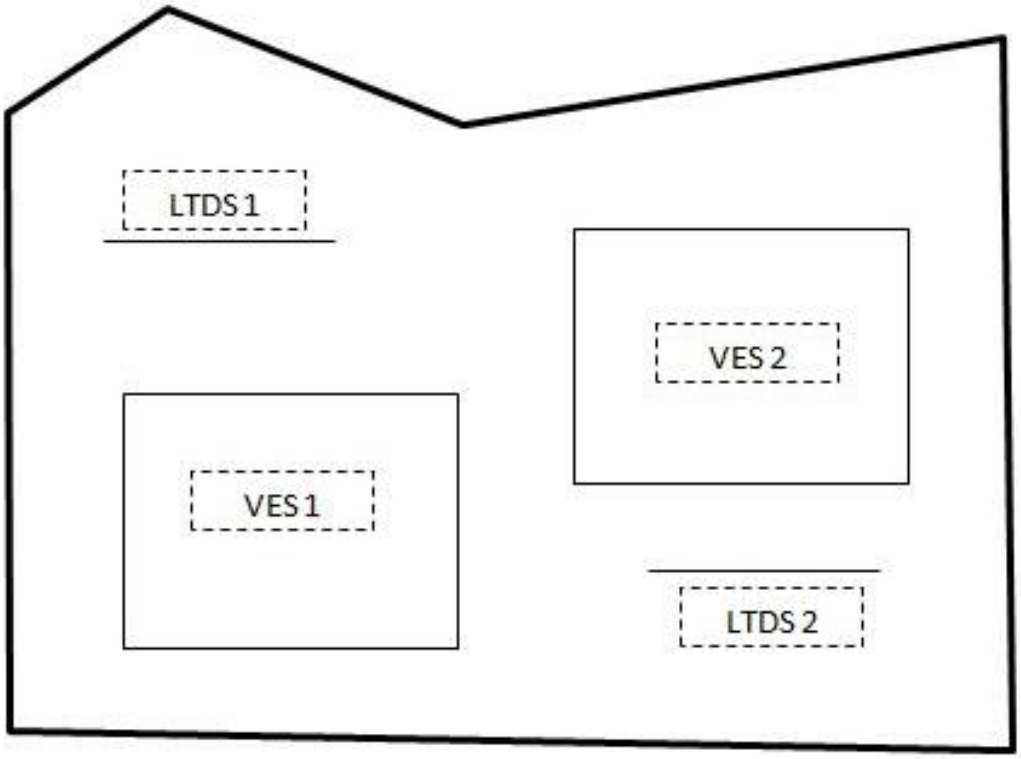

Fig 2. Typical site design for butterfly. Each site had two visual encounter surveys (VES) and two line-transect distance sampling (LTDS) transects. The LT transects were 100 m in length, and the VES areas each covered two hectares. Each observer surveyed one VES and one LT (subplot). LT were at least 100 m meters apart, and VES areas were at least 50m apart.

Butterfly occupancy

Observers used VES to determine butterfly species diversity, detection rates, and occupancy. Locating the edges with a GPS unit, observers walked throughout VES subplots for 30 minutes in a zigzag pattern (Fig 3). Observers were not restricted to where they spent their time and could search longer in areas with high floral resources. As observers walked around, they recorded all butterflies, noting the species, behavior, and number. If a butterfly could not be identified, observers suspended the survey, took a picture or attempted to capture the butterfly with a net to identify, and resumed the survey at the stopped point.

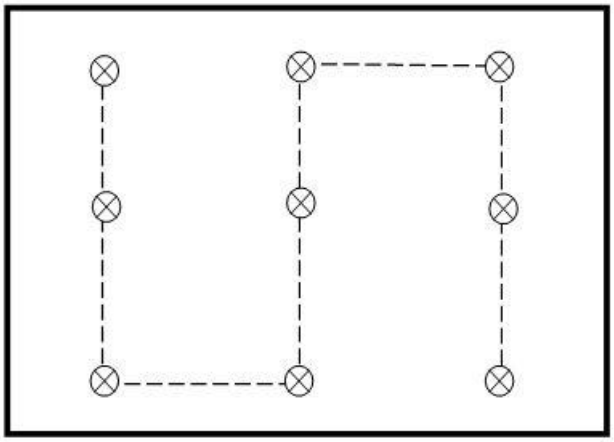

Fig 3. Visual encounter survey design for butterfly surveys. Observers walked a standardized zigzag pattern, represented by the dashed line (- - -). Observers also took visual obstruction readings with a Robel pole and recorded plant species canopy cover at nine locations (⊗).

Butterfly density

Observers used LT to determine butterfly species diversity, encounter rates, detection rates, and butterfly density. We conducted LT surveys by walking 100 m transects, marked with a measuring tape, at approximately 10 m · min^{-1} (Fig 4). Observers recorded all butterfly species detected ahead or to either side of the line. Additionally, observers estimated the perpendicular distance from the line to each individual butterfly. To accurately estimate distances, observers were trained and calibrated. If a butterfly could not be identified, observers suspended the survey, took a picture or attempted to capture the butterfly with a net to identify, and resumed the survey at the stopped point.

Fig 4. Line-transect distance sampling survey design for butterfly surveys. Observers walked a 100 m transect and estimated the perpendicular distance of all butterfly species from the line. Observers also took visual obstruction readings with a Robel pole and recorded plant species canopy cover at six locations (⊗).

Landscape variables

We collected several site variables to increase the effectiveness of detection functions and create models to determine landscape influences on certain butterfly species. To improve detection functions, we incorporated site variables such as cloud cover, time of day, temperature, and observer. We also collected visual obstruction readings (VOR) with a modified Robel pole to measure plant obstruction. To obtain the average structure, we took VOR every 20 m along line transects (n=6) and every 50 m along 3- 100 m transects in VES subplots (n=9, Figs 3 and 4). Additionally, we collected vegetation variables to aid in creating models for observed species. We counted the number of flowering ramets in 2.5 × 2.5 m belts along the same transects

used to measure VOR (Fig 5). To get site plant species community data, we used 1 × 1 m quadrat frames to measure canopy cover during peak plant production in late July. Every 20 m along the line transect (n=6) and every 50 m along the three transects placed in the VES subplots (n=9), we visually estimated canopy cover to the nearest percent and placed them in cover class (0-5, 5-10,10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, 80-90, 90-95, and 95-100).

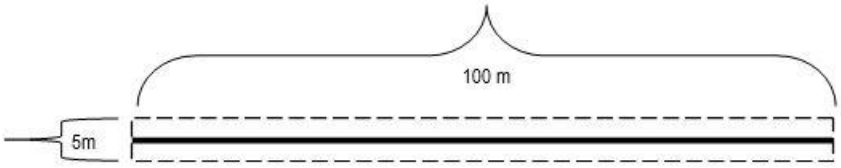

Fig 5. Belt transect design that was used in both methods to collect flowering ramet density. Along all transects (dark black line), including those in the VES plot, observers counted flowering ramets that fell within 2.5 m on either side of the transect, creating 5 x 100 m belts (dashed line).

Results

Butterfly diversity and detections

Butterfly species richness, evenness, and diversity was calculated for all sites from 2015-2017 (Table 1). In 2017, we had fewer detections (~3,800) than the 2016 survey season, but we observed more species than 2016 with 43 species (Table 2). There was a large difference in species richness and detections between the two methods used for butterfly surveys. In 2017, we detected 43 species with both methods, but the VES had more detections than LT, as observed in previous years (Table 2). We detected 36 species with LT, two of those species unique to LT. With VES, we detected 40 species, with seven unique species not found in LT. **We detected one female Dakota skipper in 2016 and 2017 at different survey locations (Fig 6).**

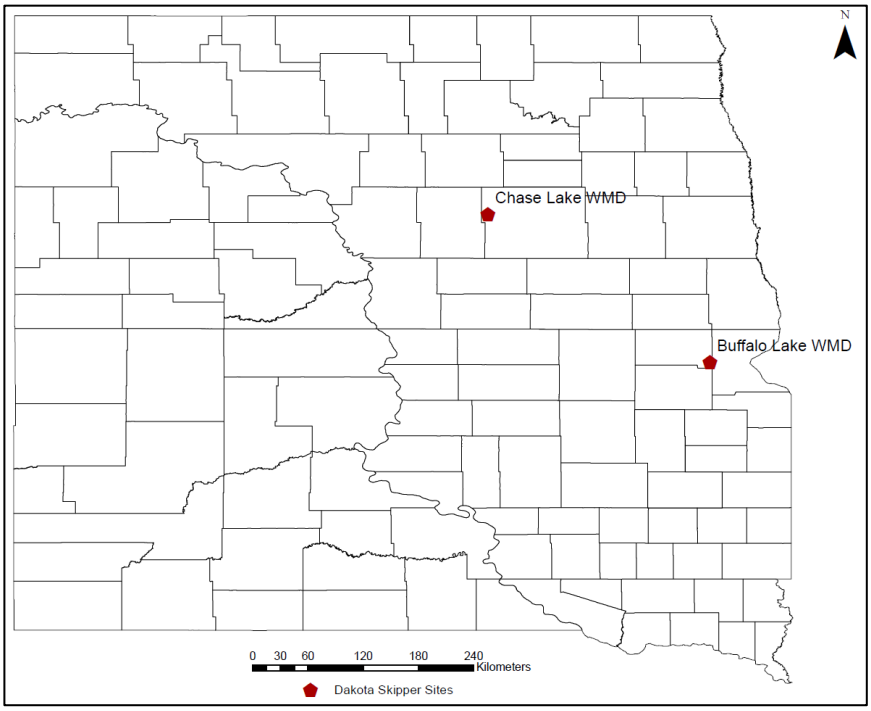

Fig 6. Dakota skipper site locations for detections in 2016 (Buffalo Lake WMD) and 2017 (Chase Lake WMD).

Table 1. Butterfly species richness, evenness, and diversity for survey sites from 2015-2017.

Site	Richness			Evenness			Shannon's			Simpson's		
	2015	2016	2017	2015	2016	2017	2015	2016	2017	2015	2016	2017
Arrowwood 14	8.00	10.00	8.00	0.81	0.80	0.822	1.55	1.74	1.63	0.74	0.77	0.76
Arrowwood 28	6.00	11.00	7.00	0.87	0.60	0.82	1.31	1.42	1.49	0.69	0.62	0.72
Bernhardt	5.00	NA	NA	0.85	NA	NA	1.25	NA	NA	0.67	NA	NA
Berwald	7.00	14.00	14.00	0.88	0.69	0.90	1.62	1.78	2.29	0.77	0.69	0.87
Bien	NA	11.00	17.00	NA	0.55	0.94	NA	1.26	2.62	NA	0.53	0.91
Biggs	NA	NA	12.00	NA	NA	0.71	NA	NA	1.74	NA	NA	0.71
Blue	NA	8.00	11.00	NA	0.43	0.82	NA	0.84	1.86	NA	0.39	0.79
Buffalo	NA	12.00	14.00	NA	0.73	0.89	NA	1.75	2.34	NA	0.74	0.89
Chase	7.00	12.00	19.00	0.71	0.79	0.88	1.28	1.95	2.56	0.60	0.81	0.90
CL	NA	11.00	16.00	NA	0.88	0.84	NA	2.02	2.29	NA	0.84	0.86
Davis 1	NA	12.00	11.00	NA	0.80	0.83	NA	1.96	1.97	NA	0.80	0.83
Davis 8	NA	12.00	14.00	NA	0.89	0.85	NA	2.11	2.18	NA	0.85	0.85
GLT	NA	10.00	13.00	NA	0.82	0.81	NA	1.88	2.05	NA	0.81	0.84
Hartleben	NA	NA	12.00	NA	NA	0.85	NA	NA	2.08	NA	NA	0.83
HB	NA	13.00	11.00	NA	0.78	0.81	NA	1.97	1.89	NA	0.83	0.80
Ilo 1	10.00	7.00	NA	0.79	0.82	NA	1.76	1.52	NA	0.79	0.72	NA
Ilo 2	11.00	11.00	12.00	0.88	0.83	0.84	2.02	1.91	1.99	0.84	0.82	0.82
LaMee	8.00	NA	NA	0.88	NA	NA	1.70	NA	NA	0.78	NA	NA
Larson 12	7.00	12.00	13.00	0.78	0.80	0.73	1.49	1.95	1.84	0.70	0.82	0.77
Larson 4	10.00	12.00	NA	0.84	0.80	NA	1.84	1.95	NA	0.80	0.80	NA
Lazy m	11.00	8.00	14.00	0.83	0.75	0.78	1.96	1.48	2.02	0.81	0.72	0.78
Lazy m 2	NA	11.00	NA	NA	0.79	NA	NA	1.83	NA	NA	0.79	NA
Manning	NA	NA	12.00	NA	NA	0.80	NA	NA	1.94	NA	NA	0.81
Melass	11.00	14.00	12.00	0.85	0.74	0.78	1.98	1.94	1.90	0.83	0.77	0.78
Rath	12.00	15.00	18.00	0.83	0.85	0.82	2.04	2.26	2.35	0.83	0.86	0.87
Red iron	7.00	11.00	17.00	0.79	0.77	0.89	1.47	1.75	2.51	0.70	0.75	0.90
Slade 1	4.00	NA	NA	0.84	NA	NA	1.13	NA	NA	0.64	NA	NA
Slade 2	5.00	NA	NA	0.90	NA	NA	1.33	NA	NA	0.70	NA	NA
Stem	NA	11.00	16.00	NA	0.64	0.82	NA	1.50	2.23	NA	0.65	0.85
Sully	NA	NA	13.00	NA	NA	0.84	NA	NA	2.15	NA	NA	0.84
Tewaukon	7.00	NA	NA	0.82	NA	NA	1.55	NA	NA	0.73	NA	NA
Unit g12	5.00	NA	NA	0.82	NA	NA	1.18	NA	NA	0.63	NA	NA
Waubay	NA	9.00	9.00	NA	0.73	0.82	NA	1.39	1.96	NA	0.67	0.84
Weber	11.00	14.00	13.00	0.81	0.88	0.76	1.89	2.31	1.85	0.81	0.89	0.76
Winberg	8.00	12.00	16.00	0.89	0.78	0.84	1.76	1.87	2.32	0.81	0.79	0.86

Table 2. Total detections for species detected with visual encounter surveys (VES) and line-transect distance sampling (LT) methods from 2015-2017.

	2015		2016		2017	
Species	**VES**	**LT**	**VES**	**LT**	**VES**	**LT**
Least skipper	0	0	0	0	0	1
Meadow fritillary	25	6	174	41	76	28
Silver-bordered fritillary	1	0	1	0	2	2
Summer azure	0	0	1	1	1	0
Common wood nymph	405	72	915	189	622	187
Gorgone checkerspot	0	0	14	5	9	4
Common ringlet	151	16	238	56	161	40
Orange sulphur	54	6	1,127	320	165	39
Clouded sulphur	360	69	457	114	374	164
Eastern Tailed-Blue	0	0	0	0	0	2
Monarch	102	22	87	17	85	24
Silver-spotted skipper	0	0	1	0	1	1
Variegated fritillary	0	0	37	8	38	10
Silvery blue	30	1	44	13	15	8
Common branded skipper	0	0	0	0	1	0
Dakota skipper	**0**	**0**	**1**	**0**	**0**	**1**
Buckeye	0	0	2	0	0	0
Viceroy	0	0	0	0	20	5
Red spotted admiral	0	0	1	0	2	0
Bronze copper	0	0	2	4	7	2
Melissa blue	70	13	106	32	183	68
Uhler's arctic	0	0	2	0	11	3
Tiger swallowtail	0	0	2	0	4	1
Black swallowtail	0	0	18	4	27	10
Common sooty wing	0	0	0	0	1	0
Tawny crescent	0	0	10	3	8	1
Northern crescent	12	1	51	25	43	12
Pearl crescent	149	37	182	27	50	19
Cabbage white	153	37	167	59	91	36
Long dash	61	18	95	25	50	20
Peck's skipper	6	0	2	0	7	1
Tawny-edged skipper	6	4	17	5	17	1
Western white	0	0	0	0	1	0
Checkered white	0	0	1	0	2	0
Checkered spotted skipper	0	0	0	1	11	2
Eyed brown	8	2	14	1	2	1
Coral hairstreak	3	1	23	4	5	1
Aphrodite fritillary	35	9	241	67	212	86
Atlantis fritllary	0	0	0	0	4	1
Great spangled fritillary	14	1	35	16	22	11
Regal fritillary	9	1	118	33	103	50
Red admiral	19	3	46	9	25	6

Painted lady	0	1	1	1	396	132
American painted lady	0	0	2	0	0	0
Dog face	0	0	0	0	1	0
Total	**1,673**	**320**	**4,235**	**1,080**	**2,855**	**980**

Butterfly occupancy and density

We are in the process of calculating occupancy for rarer species. Conversely, we have calculated butterfly density and abundance for common species. In 2017, we were able to calculate density estimates and effective strip width (esw) for 15 species, including Orange Sulphurs (*Colias eurytheme*), Clouded Sulphurs *(Colias philodice*), Monarchs (*Danaus plexippus*), Cabbage Whites (*Pieris rapae*), Northern Crescents (*Phyciodes cocyta*), Pearl Crescents (*Phyciodes tharos*), Melissa Blues (*Plebejus melissa*), Aphrodite Fritillaries (*Speyeria aphrodite*), Great Spangled Fritillaries (*Speyeria cybele*), Painted Ladies (*Vanessa cardui*), Meadow Fritillaries (*Boloria bellona*), Common Wood Nymphs (*Cercyonis pegala),* Common Ringlets (*Coenonympha tullia*), Long Dash Skippers (*Polites mystic*), and Regal Fritillaries (*Speyeria idalia*; Fig 6).

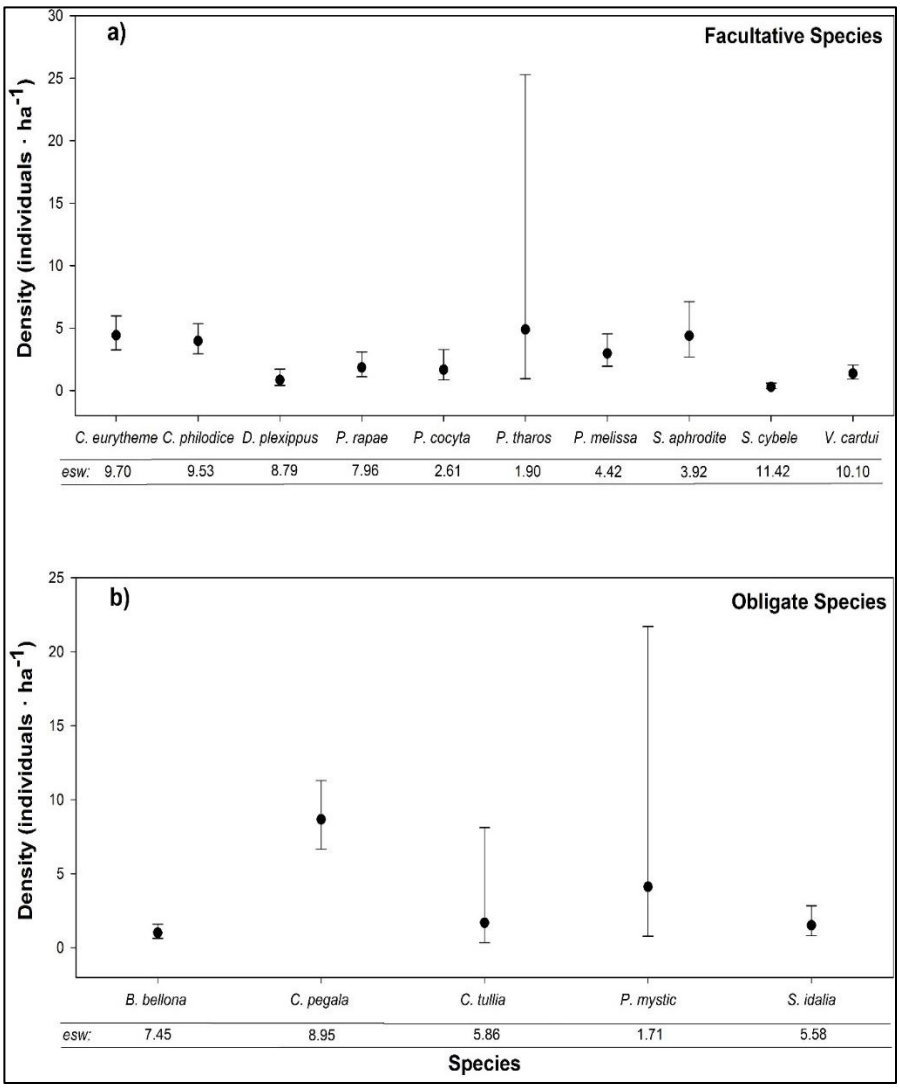

Fig 6. Butterfly density (±CI) and effective strip width (esw) for 15 species detected at least 30 times from 2015-2017. Species are designated as facultative or obligate grassland species.

Landscape variables

After we determine butterfly occupancy and density, we can start creating models to determine landscape influences on butterfly presence and abundance. These models will be created after more data has been collected to improve estimates, but we can use some of the site variables to guide future survey locations (i.e. discarding sites with low plant and butterfly diversity). Some of the data that we collected onsite that will go into our models are visual obstruction (Table 3), flowering forb density (Table 4) and diversity (Table 5), and plant species diversity (Table 6). We will also include other derived variables like the cover of cool-season invasive grasses (Table 7) and forbs (Table 8).

Table 3. Mean visual obstruction readings (VOR) found for each site with a Robel pole from 2015-2017.

	Average VOR Reading		
Site	**2015**	**2016**	**2017**
Arrowwood 14	5.17	2.79	1.45
Arrowwood 28	2.38	2.29	1.37
Bernhardt	3.23	NA	NA
Berwald	3.37	3.00	3.04
Bien	NA	1.81	1.16
Biggs	NA	NA	3.32
Blue	NA	2.81	1.90
Buffalo	NA	1.04	1.20
Chase	2.47	1.42	1.58
CL	NA	2.04	1.18
Davis 8	NA	1.46	1.07
Davis 1	NA	2.17	1.42
GLT	NA	1.79	1.20
Hartleben	NA	NA	1.30
HB	NA	1.67	1.68
Ilo 1	3.93	1.42	NA
Ilo 2	1.66	1.13	1.21
LaMee	4.23	NA	NA
Larson 12	3.99	2.38	1.79
Larson 4	3.92	1.25	NA
Lazy m	3.08	3.13	1.45
Lazy m 2	NA	2.25	NA
Manning	NA	NA	1.13
Melass	3.67	3.88	2.60
Rath	4.05	3.46	1.45
Red iron	3.80	2.46	1.94
Slade 1	3.74	NA	NA
Slade 2	2.80	NA	NA
Stem	NA	3.13	2.35
Sully	NA	NA	1.63
Tewaukon	2.73	NA	NA
Unit g12	2.31	NA	NA
Waubay	NA	2.21	2.19
Weber	2.80	2.13	1.36
Winberg	3.42	2.42	1.94

Table 4. Flowering forb density for each site from 2015-2017.

	Average Total Flowering per 500m^2		
Site	**2015**	**2016**	**2017**
Arrowwood 14	489.16	302.11	127.67
Arrowwood 28	211.05	1,593.89	72.33
Bernhardt	39.06	NA	NA
Berwald	276.28	268.00	107.00
Bien	NA	384.56	68.47
Biggs	NA	NA	506.72
Blue	NA	308.72	114.92
Buffalo	NA	279.72	57.75
Chase	376.04	462.11	115.03
CL	NA	771.44	315.64
Davis 8	NA	301.89	23.69
Davis 1	NA	409.83	125.19
GLT	NA	160.33	78.42
Hartleben	NA	NA	40.92
HB	NA	1,638.00	261.06
Ilo 1	386.03	43.22	NA
Ilo 2	258.17	653.78	123.11
LaMee	83.97	NA	NA
Larson 12	158.53	478.17	110.56
Larson 4	211.16	672.78	NA
Lazy m	163.14	582.50	97.83
Lazy m 2	NA	2,801.00	NA
Manning	NA	NA	99.33
Melass	189.97	253.83	129.06
Rath	289.72	248.50	43.14
Red iron	227.81	454.00	91.75
Slade 1	182.11	NA	NA
Slade 2	61.75	NA	NA
Stem	NA	485.72	344.14
Sully	NA	NA	126.61
Tewaukon	180.17	NA	NA
Unit g12	99.28	NA	NA
Waubay	NA	434.00	72.53
Weber	275.97	385.06	158.67
Winberg	493.18	529.28	290.14

Table 5. Flowering forb richness, evenness, and diversity for each site based off of belt transects from 2015-2017.

	Richness			Evenness			Shannon's			Simpson's		
Site	**2015**	**2016**	**2017**	**2015**	**2016**	**2017**	**2015**	**2016**	**2017**	**2015**	**2016**	**2017**
Arrowwood 14	30.00	35.00	29.00	0.44	0.80	0.75	1.47	2.79	2.48	0.58	0.91	0.87
Arrowwood 28	21.00	23.00	21.50	0.46	0.40	0.53	1.37	1.21	1.61	0.59	0.52	0.64
Bernhardt	15.00	NA	NA	0.62	NA	NA	1.57	NA	NA	0.72	NA	NA
Berwald	45.00	44.00	44.50	0.8	0.77	0.81	3.04	2.89	3.06	0.94	0.91	0.93
Bien	NA	41.00	43.00	NA	0.71	0.76	NA	2.61	2.86	NA	0.85	0.90
Biggs	NA	NA	25.50	NA	NA	0.41	NA	NA	1.31	NA	NA	0.56
Blue	NA	28.00	34.50	NA	0.68	0.70	NA	2.25	2.48	NA	0.84	0.87
Buffalo	NA	25.00	40.00	NA	0.74	0.82	NA	2.38	2.98	NA	0.85	0.93
Chase	32.00	31.00	28.00	0.42	0.69	0.69	1.45	2.35	2.28	0.54	0.83	0.84
CL	NA	40.00	33.00	NA	0.71	0.70	NA	2.61	2.46	NA	0.89	0.86
Davis 8	NA	42.00	26.00	NA	0.78	0.86	NA	2.90	2.77	NA	0.91	0.92
Davis 1	NA	42.00	33.00	NA	0.66	0.75	NA	2.42	2.54	NA	0.85	0.88
GLT	NA	29.00	27.50	NA	0.63	0.79	NA	2.09	2.59	NA	0.74	0.89
Hartleben	NA	NA	14.50	NA	NA	0.66	NA	NA	1.62	NA	NA	0.68
HB	NA	38.00	25.00	NA	0.44	0.43	NA	1.60	1.37	NA	0.59	0.54
Ilo 1	18.00	13.00	NA	0.56	0.64	NA	1.62	1.63	NA	0.74	0.70	NA
Ilo 2	30.00	25.00	21.00	0.61	0.62	0.66	2.05	1.99	1.97	0.77	0.80	0.78
LaMee	26.00	NA	NA	0.65	NA	NA	2.09	NA	NA	0.81	NA	NA
Larson 12	26.00	27.00	19.00	0.65	0.72	0.68	2.09	2.32	1.99	0.79	0.86	0.79
Larson 4	31.00	32.00	NA	0.67	0.47	NA	2.28	1.60	NA	0.83	0.66	NA
Lazy m	31.00	35.00	20.00	0.64	0.73	0.55	2.28	2.60	1.64	0.82	0.89	0.71
Lazy m 2	NA	30.00	NA	NA	0.39	NA	NA	1.34	NA	NA	0.63	NA
Manning	NA	NA	28.50	NA	NA	0.72	NA	NA	2.38	NA	NA	0.86
Melass	34.00	31.00	25.00	0.72	0.68	0.68	2.5	2.31	2.17	0.88	0.84	0.81
Rath	29.00	30.00	20.00	0.7	0.69	0.64	2.33	2.35	1.86	0.85	0.86	0.72
Red iron	37.00	38.00	37.00	0.71	0.68	0.71	2.55	2.45	2.55	0.89	0.88	0.86
Slade 1	13.00	NA	NA	0.29	NA	NA	0.73	NA	NA	0.34	NA	NA
Slade 2	22.00	NA	NA	0.7	NA	NA	2.12	NA	NA	0.82	NA	NA
Stem	NA	39.00	41.50	NA	0.72	0.64	NA	2.63	2.38	NA	0.89	0.84
Sully	NA	NA	20.50	NA	NA	0.59	NA	NA	1.77	NA	NA	0.74
Tewaukon	22.00	NA	NA	0.72	NA	NA	2.2	NA	NA	0.83	NA	NA
Unit g12	22.00	NA	NA	0.57	NA	NA	1.74	NA	NA	0.69	NA	NA
Waubay	NA	25.00	22.50	NA	0.54	0.57	NA	1.73	1.79	NA	0.74	0.71
Weber	35.00	39.00	33.50	0.68	0.75	0.71	2.41	2.74	2.48	0.85	0.91	0.87
Winberg	29.00	25.00	25.50	0.52	0.56	0.62	1.75	1.79	1.98	0.68	0.71	0.74

Table 6. Plant species richness, evenness, and diversity for all sites from 2015-2017.

Site	Richness	Evenness	Shannon Diversity	Simpson's Diversity
Arrowwood 14	26.00	0.75	2.40	0.86
Arrowwood 28	15.00	0.66	1.74	0.76
Bernhardt	17.00	0.42	1.20	0.58
Berwald	27.00	0.77	2.47	0.86
Bien	15.00	0.71	1.92	0.80
Biggs	25.00	0.84	2.69	0.91
Blue	15.00	0.72	1.86	0.76
Buffalo	17.00	0.72	2.00	0.76
Chase	15.00	0.67	1.77	0.74
CL	28.00	0.72	2.39	0.85
Davis 8	20.00	0.73	2.14	0.80
Davis 1	20.00	0.83	2.45	0.89
GLT	14.00	0.64	1.70	0.73
Hartleben	20.00	0.80	2.40	0.88
HB	20.00	0.84	2.46	0.89
Ilo 1	10.00	0.59	1.28	0.63
Ilo 2	21.00	0.74	2.20	0.83
LaMee	29.00	0.56	1.89	0.71
Larson 12	15.00	0.63	1.65	0.72
Larson 4	19.00	0.59	1.66	0.70
Lazy m	17.00	0.66	1.80	0.74
Lazy m 2	11.00	0.76	1.83	0.77
Manning	31.00	0.80	2.73	0.91
Melass	19.00	0.75	2.17	0.83
Rath	19.00	0.61	1.78	0.69
Red iron	25.00	0.79	2.49	0.88
Slade 1	9.00	0.64	1.36	0.66
Slade 2	21.00	0.68	2.04	0.80
Stem	17.00	0.70	1.96	0.78
Sully	32.00	0.82	2.82	0.92
Tewaukon	20.00	0.67	1.98	0.79
Unit g12	18.00	0.60	1.68	0.72
Waubay	10.00	0.77	1.76	0.77
Weber	21.00	0.69	2.05	0.79
Winberg	21.00	0.68	1.98	0.78

Table 7. Average canopy cover of Kentucky bluegrass and smooth brome for each site from 2015-2017.

	Kentucky bluegrass			Smooth brome		
Site	**2015**	**2016**	**2017**	**2015**	**2016**	**2017**
Arrowwood 14	23.60	23.56	20.13	9.93	10.67	5.04
Arrowwood 28	27.47	12.56	19.19	20.72	24.78	32.06
Bernhardt	36.07	NA	NA	22.35	NA	NA
Berwald	18.94	9.22	19.86	22.54	23.89	24.31
Bien	NA	18.44	10.40	NA	27.44	16.03
Biggs	NA	NA	18.99	NA	NA	1.18
Blue	NA	11.22	6.90	NA	1.67	14.60
Buffalo	NA	5.56	26.61	NA	19.11	15.82
Chase	19.83	32.67	18.90	34.06	18.89	2.92
CL	NA	25.92	11.53	NA	1.83	2.83
Davis 1	NA	29.00	12.31	NA	1.11	4.58
Davis 8	NA	11.00	29.76	NA	3.89	8.75
GLT	NA	29.00	28.39	NA	17.44	7.03
Hartleben	NA	NA	20.21	NA	NA	3.35
HB	NA	10.44	15.28	NA	0.00	19.44
Ilo 1	14.43	21.33	NA	13.78	16.56	NA
Ilo 2	19.76	21.00	25.90	13.11	12.00	9.38
LaMee	13.79	NA	NA	42.78	NA	NA
Larson 12	36.17	27.89	25.17	20.89	33.78	24.61
Larson 4	15.43	14.22	NA	43.07	32.22	NA
Lazy m	15.81	44.67	22.76	41.78	23.78	32.06
Lazy m2	NA	14.56	NA	NA	34.44	NA
Manning	NA	NA	6.88	NA	NA	0.33
Melass	26.43	28.44	25.00	20.85	13.89	15.26
Rath	11.36	15.89	13.51	40.61	47.44	41.82
Red iron	23.54	15.11	17.66	15.86	7.22	12.46
Slade 1	31.88	NA	NA	18.61	NA	NA
Slade 2	20.32	NA	NA	23.76	NA	NA
Stem	NA	5.11	7.44	NA	1.67	0.42
Sully	NA	NA	6.08	NA	NA	0.72
Tewaukon	27.83	NA	NA	20.40	NA	NA
Unit g12	19.46	NA	NA	23.94	NA	NA
Waubay	NA	20.11	12.93	NA	24.67	31.93
Weber	33.58	22.69	26.35	25.33	8.00	20.39
Winberg	33.11	16.57	16.56	14.89	33.89	23.42
Average	**23.44**	**19.42**	**17.87**	**24.42**	**17.61**	**14.26**

Table 8. Average flowering counts for sweetclover from belt transects on each site from 2015-2017.

	Average Flowering Sweetclover per 500m^2		
Site	**2015**	**2016**	**2017**
Arrowwood 14	306.81	10.28	24.50
Arrowwood 28	0.06	1,062.22	0.06
Bernhardt	0.78	NA	NA
Berwald	18.11	63.67	4.86
Bien	NA	7.11	9.36
Biggs	NA	NA	384.81
Blue	NA	0.00	0.50
Buffalo	NA	1.06	8.75
Chase	260.90	158.67	21.42
CL	NA	51.22	94.58
Davis 1	NA	1.61	0.92
Davis 8	NA	0.17	6.64
GLT	NA	0.22	0.00
Hartleben	NA	NA	28.22
HB	NA	0.33	0.44
Ilo 1	101.67	41.50	NA
Ilo 2	0.25	85.72	51.03
LaMee	16.33	NA	NA
Larson 12	7.42	87.44	16.69
Larson 4	52.24	168.72	NA
Lazy m	14.11	122.22	2.86
Lazy m2	NA	868.28	NA
Manning	NA	NA	30.53
Melass	3.81	0.39	0.00
Rath	92.92	43.67	1.44
Red iron	0.00	1.11	0.03
Slade 1	2.36	NA	NA
Slade 2	12.42	NA	NA
Stem	NA	0.00	1.67
Sully	NA	NA	0.11
Tewaukon	54.64	NA	NA
Unit g12	0.50	NA	NA
Waubay	NA	83.56	1.11
Weber	48.25	59.11	32.97
Winberg	38.89	1.94	22.81

Appendix
Species list and abundances for each National Wildlife Refuge (NWR) or Wetland Management District (WMD) where surveys were conducted from 2015-2017.

A1. Species list and abundance for each site surveyed at Arrowwood NWR from 2015-2017. The abundance is the total count for each species over all surveys. The number of years surveys were conducted at each site are listed in parentheses after site names.

	Arrowwood NWR	
Species	*Arrowwood G14 (3)*	*Arrowwood G28 (3)*
Meadow Fritillary	9	12
Summer Azure	0	0
Common Wood Nymph	95	54
Common Ringlet	1	3
Orange Sulphur	38	144
Clouded Sulphur	40	61
Monarch	7	13
Silver-spotted Skipper	1	0
Variegated Fritillary	1	0
Silvery Blue	0	1
Viceroy	0	1
Melissa Blue	1	3
Pearl Crescent	1	2
Cabbage White	66	13
Long Dash Skipper	8	0
Checkered Skipper	0	1
Coral Hairstreak	3	0
Aphrodite Fritillary	122	6
Great Spangled Fritillary	1	0
Regal Fritillary	3	2
Red Admiral	18	5
Painted Lady	24	34

A2. Species list and abundance for each site surveyed at Chase Lake WMD from 2015-2017. The abundance is the total count for each species over all surveys. The number of years surveys were conducted at each site are listed in parentheses after site names.

	Chase Lake WMD			
Species	*Chase Lake (3)*	*CL (2)*	*Weber (3)*	*Winberg (3)*
Meadow Fritillary	11	0	25	14
Silver-bordered Fritillary	1	3	0	1
Summer Azure	1	0	1	0
Common Wood Nymph	30	45	123	59
Gorgone's Checkerspot	3	4	0	10
Common Ringlet	20	8	48	29
Orange Sulphur	59	35	50	59
Clouded Sulphur	110	51	91	97
Monarch	3	0	7	3
Variegated Fritillary	2	8	0	1
Silvery Blue	10	3	1	6
Common Branded Skipper	0	1	0	0
Dakota Skipper	1	0	0	0
Bronze Copper	2	0	1	2
Melissa Blue	26	29	30	2
Uhler's Arctic	0	11	0	0
Black Swallowtail	1	1	1	3
Tawny Crescent	0	0	1	2
Northern Crescent	0	0	8	4
Pearl Crescent	11	1	59	23
Cabbage White	16	15	15	13
Long Dash Skipper	1	3	28	22
Peck's Skipper	1	0	1	0
Checkered White	0	1	1	1
Eyed Brown	1	0	0	7
Aphrodite Fritillary	2	44	26	2
Great Spangled Fritillary	6	15	3	4
Regal Fritillary	1	9	2	1
Red Admiral	12	5	5	3
Painted Lady	9	10	11	9

A3. Species list and abundance for each site surveyed at Devils Lake WMD from 2015-2017. The abundance is the total count for each species over all surveys. The number of years surveys were conducted at each site are listed in parentheses after site names.

Devils Lake WMD		
Species	*Melass (3)*	*Sully's Hill (1)*
Meadow Fritillary	1	4
Silver-bordered Fritillary	1	0
Summer Azure	1	0
Common Wood Nymph	233	44
Common Ringlet	54	2
Orange Sulphur	70	14
Clouded Sulphur	61	31
Monarch	13	7
Variegated Fritillary	0	7
Silvery Blue	1	0
Viceroy	1	0
White Admiral	0	2
Bronze Copper	4	0
Melissa Blue	6	2
Tawny Crescent	4	1
Northern Crescent	42	0
Pearl Crescent	93	0
Cabbage White	24	7
Long Dash Skipper	17	0
Peck's Skipper	1	0
Tawny-edged Skipper	0	1
Eyed Brown	3	0
Aphrodite Fritillary	39	10
Great Spangled Fritillary	0	2
Red Admiral	11	4
Painted Lady	25	17

A4. Species list and abundance for each site surveyed at Kulm WMD from 2015-2017. The abundance is the total count for each species over all surveys. The number of years surveys were conducted at each site are listed in parentheses after site names.

	Kulm WMD			
Species	*Larson WPA 12 (3)*	*Larson WPA 4 (2)*	*Lazy M (3)*	*Lazy M 2 (1)*
Meadow Fritillary	2	5	60	31
Common Wood Nymph	205	67	105	43
Common Ringlet	15	15	5	23
Orange Sulphur	72	52	64	67
Clouded Sulphur	60	29	44	36
Monarch	12	5	10	0
Silvery Blue	2	15	0	14
Viceroy	0	0	1	0
Bronze Copper	1	1	0	1
Melissa Blue	1	0	6	1
Tawny Crescent	2	0	0	0
Northern Crescent	21	5	0	0
Pearl Crescent	34	30	2	8
Cabbage White	3	5	49	1
Long Dash Skipper	7	6	13	6
Peck's Skipper	0	0	0	0
Tawny-edged Skipper	0	0	2	1
Eyed Brown	2	0	0	10
Coral Hairstreak	0	0	0	0
Aphrodite Fritillary	55	3	17	1
Great Spangled Fritillary	4	0	0	0
Regal Fritillary	9	2	10	1
Red Admiral	2	3	3	1
Painted Lady	40	0	3	0
American Painted Lady	0	1	0	0
Dog Face	1	0	0	0

A5. Species list and abundance for each site surveyed at Lake Ilo NWR from 2015-2017. The abundance is the total count for each species over all surveys. The number of years surveys were conducted at each site are listed in parentheses after site names.

Lake Ilo NWR		
Species	*Lake Ilo 1 (2)*	*Lake Ilo 2 (3)*
Meadow Fritillary	1	1
Common Wood Nymph	49	52
Common Ringlet	11	42
Orange Sulphur	16	56
Clouded Sulphur	62	93
Variegated Fritillary	0	4
Silvery Blue	14	0
Melissa Blue	40	71
Uhler's Arctic	0	2
Common Sooty Wing	0	1
Pearl Crescent	0	7
Cabbage White	9	21
Long Dash Skipper	12	5
Peck's Skipper	0	5
Tawny-edged Skipper	1	22
Aphrodite Fritillary	0	7
Great Spangled Fritillary	2	5
Regal Fritillary	1	8
Red Admiral	1	4
Painted Lady	0	3

A6. Species list and abundance for each site surveyed at Slade NWR in 2015. The abundance is the total count for each species over all surveys. The number of years surveys were conducted at each site are listed in parentheses after site names.

Slade NWR		
Species	*Slade 1 (1)*	*Slade 2 (1)*
Common Wood Nymph	15	17
Common Ringlet	0	4
Orange Sulphur	0	4
Clouded Sulphur	10	20
Monarch	1	0
Melissa Blue	0	2
Pearl Crescent	1	1
Cabbage White	11	6

A7. Species list and abundance for each site surveyed at Long Lake WMD from 2015-2017. The abundance is the total count for each species over all surveys. The number of years surveys were conducted at each site are listed in parentheses after site names.

	Long Lake WMD		
Species	*Bernhardt (1)*	*Rath/Wonnenburg (3)*	*Unit G-12 (1)*
Meadow Fritillary	0	1	0
Common Wood Nymph	2	115	7
Common Ringlet	0	80	0
Orange Sulphur	0	68	1
Clouded Sulphur	13	83	17
Monarch	0	21	5
Variegated Fritillary	0	3	0
Silvery Blue	7	16	0
Bronze Copper	0	1	0
Melissa Blue	3	42	5
Black Swallowtail	0	2	0
Tawny Crescent	0	4	0
Northern Crescent	0	38	0
Pearl Crescent	1	121	0
Cabbage White	0	21	28
Long Dash Skipper	0	37	0
Peck's Skipper	0	2	0
Tawny-edged Skipper	0	2	0
Checkered Skipper	0	2	0
Eyed Brown	0	2	0
Aphrodite Fritillary	0	18	0
Regal Fritillary	0	1	0
Red Admiral	1	4	0
Painted Lady	1	11	0

A8. Species list and abundance for each site surveyed at Upper Souris NWR from 2016-2017. The abundance is the total count for each species over all surveys. The number of years surveys were conducted at each site are listed in parentheses after site names.

Upper Souris NWR		
Species	*GLT A (2)*	*HB-24 Ekert Ranch South (2)*
Meadow Fritillary	19	1
Common Wood Nymph	70	65
Common Ringlet	60	34
Orange Sulphur	48	79
Clouded Sulphur	59	58
Monarch	2	1
Variegated Fritillary	3	6
Melissa Blue	3	14
Tawny Crescent	0	1
Pearl Crescent	6	1
Cabbage White	83	45
Long Dash Skipper	8	5
Tawny-edged Skipper	4	4
Western White	1	0
Checkered Skipper	3	0
Aphrodite Fritillary	68	69
Atlantis Fritillary	5	0
Great Spangled Fritillary	2	4
Regal Fritillary	5	4
Red Admiral	0	1
Painted Lady	49	62

A9. Species list and abundance for each site surveyed at Tewaukon NWR from 2015 and 2017. The abundance is the total count for each species over all surveys. The number of years surveys were conducted at each site are list in parentheses after site names.

Tewaukon NWR			
Species	Biggs (1)	*Hartleben (1)*	*Tewaukon 100 (1)*
Least Skipper	0	1	0
Meadow Fritillary	5	0	0
Common Wood Nymph	4	7	7
Orange Sulphur	10	15	12
Clouded Sulphur	23	13	45
Eastern Tailed Blue	0	2	0
Monarch	7	11	27
Viceroy	5	1	0
Melissa Blue	4	15	0
Black Swallowtail	1	0	0
Tawny Crescent	3	0	0
Northern Crescent	6	5	0
Pearl Crescent	5	1	9
Cabbage White	4	7	8
Eyed Brown	0	0	2
Aphrodite Fritillary	0	2	0
Atlantis Fritillary	0	0	0
Great Spangled Fritillary	3	1	0
Regal Fritillary	1	5	0
Red Admiral	1	0	2
Painted Lady	72	49	0

A10. Species list and abundance for each site surveyed at Waubay WMD from 2015-2017. The abundance is the total count for each species over all surveys. The number of years surveys were conducted at each site are list in parentheses after site names.

	Waubay WMD				
Species	*Berwald (3)*	*Buffalo Lake (2)*	*N LaMee (1)*	*Red Iron Lake (3)*	*Waubay NWR (2)*
Meadow Fritillary	9	19	1	11	6
Common Wood Nymph	42	18	11	87	56
Gorgone's Checkerspot	0	0	0	2	0
Common Ringlet	46	6	8	13	4
Orange Sulphur	115	81	1	93	91
Clouded Sulphur	27	35	5	48	28
Monarch	50	16	2	48	20
Silver-spotted Skipper	0	1	0	0	0
Variegated Fritillary	3	31	0	1	1
Silvery Blue	0	0	0	10	2
Dakota Skipper	0	1	0	0	0
Buckeye	0	0	0	0	1
Viceroy	1	1	0	0	0
White Admiral	0	0	0	0	0
Bronze Copper	0	0	0	1	0
Melissa Blue	4	34	0	6	1
Eastern Tiger Swallowtail	1	0	0	0	1
Black Swallowtail	10	4	0	4	1
Tawny Crescent	3	0	0	0	0
Northern Crescent	2	0	0	2	1
Pearl Crescent	30	1	1	2	0
Cabbage White	8	5	1	8	2
Long Dash Skipper	13	0	15	9	2
Peck's Skipper	1	1	0	0	0
Tawny-edged Skipper	4	0	0	4	0
Coral Hairstreak	4	0	0	3	0
Aphrodite Fritillary	0	3	0	28	1
Great Spangled Fritillary	13	2	0	10	2
Regal Fritillary	9	20	0	49	6
Red Admiral	4	0	0	9	2
Painted Lady	18	11	0	11	6
American Painted Lady	1	0	0	0	0